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Short Communication

Direct Measurement of Intra-abdominal Pressures in a Horse by Using a Solid Microsensor

Elizabeth J. Barrett DVM, Amelia S. Munsterman DVM, MS, DACVS, DACVECC, Valeria Albanese DVM, R. Reid Hanson DVM, DACVS, DACVECC

Department of Clinical Sciences, College of Veterinary Medicine, Auburn University, Auburn, AL

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ABSTRACT

Current techniques to measure intra-abdominal pressures in horses use metal cannulas. Concerns that the metal cannula could puncture abdominal viscera if left in place prevent continual pressure measurements. The aim of this study was to validate the use of a solid microsensor and digital monitoring system in the measurement of direct intra-abdominal pressure in horses by comparing its values with the ones simultaneously obtained by means of an intraperitoneal cannula. Ten healthy adult horses had intra-abdominal pressures measured simultaneously through an intraperitoneal cannula zeroed midway between the height of the tuber ishii and point of the shoulder and by the use of an intraperitoneal solid microsensor placed within the abdomen at the same level as the metal cannula. Three repeated intra-abdominal pressure measurements were obtained at rest, after placement of a nasogastric tube, and after placement of 5-L increments of water into the stomach, up to a total volume of 20 L of water. The difference between values obtained (after conversion) was 3.6 mm Hg. The correlation coefficient was 0.825. Direct intra-abdominal pressure monitoring with a solid microsensor allows continuous monitoring without concern for gastrointestinal perforation, is simple to use and to calibrate, and is minimally invasive.

1. Introduction

Intra-abdominal pressure (IAP) is related to compliance of the abdominal wall and the volume of abdominal contents. Excessive and/or sustained increases in pressures within the abdomen are termed intra-abdominal hypertension, which is a recognized pathologic condition in both humans and animals [1,2]. Intra-abdominal pressures above 40 cm H_2O may result in organ failure in affected human patients, and this condition is known as abdominal compartment syndrome [1,3-6].

Current techniques for measuring abdominal pressures in human medicine consist of either direct (within the abdomen) or indirect (within the bladder or stomach) approaches using both rigid and malleable instrumentation. Typically, human patients monitored for intra-abdominal hypertension are on mechanical ventilation in a vegetative state or are under heavy sedation and unable to resist diagnostic procedures. Techniques for measuring IAP in humans may not be applicable for continuous monitoring of IAP in an awake, mobile equine patient. The currently accepted method for measuring intra-abdominal pressures in horses is a metal cannula that allows for measurements to be taken only while the horse is restrained and standing quietly over concerns that the metal cannula could dislodge or cause damage to abdominal viscera. Additionally, the metal cannula can cause horses to react to the sensation and splint against it, which may increase measured pressures, as noted in human patients [4]. This solid microsensor is attached to a malleable cable and has already been validated for use in humans for the measurement of intra-abdominal and intracranial pressures [6]. We set out in this study to validate the use of a solid microsensor[1] to allow for repeated,

Corresponding author at: Elizabeth J. Barrett, DVM, Department of Clinical Sciences, College of Veterinary Medicine, Auburn University, Auburn, Alabama 36849.

E-mail address: ezb0021@auburn.edu (E.J. Barrett).

[1] Intracranial pressure monitoring system, DePuy Synthes, Warsaw, IN.

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less invasive measurements of direct intraperitoneal IAP in horses.

2. Materials and Methods

2.1. Horses

All procedures were approved by the University's Institutional Animal Care and Use Committee. Ten healthy adult horses, including 3 mares and 7 geldings, weighing an average of 546 kg (range, 481-670 kg) with a median age of 17 years (range, 11-22 years) were used in this investigation. Breeds represented included Thoroughbred (3), Tennessee Walking Horse (1), Arabian (2), Warmblood (2), American Quarter Horse (1), and American Paint Horse (1). Each horse was fasted for 24 hours before the initiation of the procedure, with water being withheld for the last 3 hours. Fasting was instituted to reduce the effects of intestinal fill on the pressure measurements, and water was withheld to minimize alterations in gastric volume.

2.2. Instrumentation

On the day of the procedures, the horses were weighed and restrained in stocks, and vital parameters including heart rate, respiratory rate, temperature, gastrointestinal borborygmi, digital pulses, mucous membrane color, and capillary refill time were obtained. The horses were then sedated with detomidine hydrochloride[2] (0.01 mg/kg), intravenously. Direct intra-abdominal pressure measurements were acquired using two methods. The first method was a modified abdominocentesis procedure previously described [7]. Briefly, the height of the midpoint of the tuber ishii and the height of the point of the shoulder were measured and then averaged to obtain the height of a point midway between the two reference points. This measurement was used as the height for insertion of the teat cannula into the abdomen, approximately 8 cm caudal to the last rib on the right side of the horse. The selected area was clipped and aseptically prepared, and the skin and subcutaneous tissues were anesthetized with 2% mepivicaine[3] (100 mg per horse). A stab incision was made into the skin and subcutaneous tissues with a number 15 blade to allow for blunt introduction of a 10-cm teat cannula into the peritoneal cavity. Entrance into the peritoneal cavity was confirmed by the loss of resistance to pressure, as felt by the operator when the cannula passed through the peritoneum. The cannula was flushed and capped with a closed extension set before introduction to reduce entrainment of air. Sterile, water-based lubricant was also applied after introduction of the cannula around the site of entry to reduce the entrance of air. For intraperitoneal pressure measurement using this cannula, the extension set was connected to a water manometer. A solid fluid column was established from the manometer to the abdomen, using balanced electrolyte solution, and readings were obtained by positioning a three-way stopcock open to the manometer. The manometer was zeroed at the height of insertion of the cannula, and the horse's head was maintained at the level of the withers throughout the experiment.

The second method used a solid microsensor (Fig. 1) placed at the same height as the cannula at a location 14 cm caudal to the last rib, again on the right side of the horse. Prior to placement within the abdomen, the microsensor was zeroed within a fluid medium,[4] as directed by the manufacturer. An open-ended metal cecal cannula (Fig. 2) was placed intraperitoneally at this location in the same fashion as the first metal cannula. The obturator was removed, and the microsensor was fed through the cannula into the abdomen. After the cannula was fed 12 cm into the abdomen, it was removed from the body wall and secured to the stocks, leaving only the microsensor in place within the abdomen. The microsensor was then connected to a monitoring device[5] that displayed the measured pressures in mm Hg.

2.3. Intra-abdominal Pressure Measurement

After instrumentation, simultaneous measurement of intra-abdominal pressures from both of these methods began approximately 30 minutes after sedation was administered to reduce the effect of sedation on pressures. Values for intra-abdominal pressure were recorded at end-inspiration when abdominal muscles were relaxed, and three separate measurements were taken at each observation. Intra-abdominal pressures were first measured at rest. A premeasured nasogastric tube was then passed through the left nostril to the level of the stomach. Five minutes was allowed to elapse after passage of the tube to allow for abdominal pressure to equilibrate, and then measurements were taken before infusing water into the stomach. Next, 5 L of water was instilled into the stomach using a hand pump, and the end of the nasogastric tube was capped. Again, 5 minutes was allowed to elapse prior to intra-abdominal pressure measurements being taken. The same procedure was repeated after a total of 10, 15, and 20 L of water had been instilled into the stomach. All measurements from instillation of the initial 5 L of fluid to the final measurement with a total of 20 L instilled into the stomach were obtained in less than 30 minutes. After the final pressure measurements were obtained, excess water was siphoned off the stomach and the nasogastric tube removed. This method of gastric distension has previously been shown to cause significant increases in intra-abdominal pressures [8].

3. Statistical Methods

A total of 180 intra-abdominal pressure measurements were taken for this study to evaluate the correlation between the two methods of abdominal pressure measurement. Abdominal pressures were averaged for each of the triplicate measurements and the numbers analyzed by a commercial statistical program.[6] Data were found to be normally distributed by using an Anderson

[2] Detomidine hydrochloride, Pfizer Animal Health, Exton, PA.
[3] Mepivicaine hydrochloride, Pfizer Animal Health, New York, NY.
[4] 0.9% saline solution, Baxter Healthcare Corp., Deerfield, IL.
[5] 3 Parameter Advisor vital signs monitor, Surgivet; Smiths Medical, Dublin, OH.
[6] Minitab 16 statistical software, State College, PA.